REAL-TIME DATA SYSTEM

MISSION OPERATIONS DIRECTORATE
RECONFIGURATION MANAGEMENT OFFICE

SSF EVOLUTION SYMPOSIUM - GROUND SYSTEMS AUTOMATION
FEBRUARY 7, 1990

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SSF EVOLUTION SYMPOSIUM GROUND SYSTEMS AUTOMATION

- GROUND SYSTEMS WILL BE CRITICAL IN EARLY SSF PROGRAM (1995-1997) DUE TO EXTENDED ASSEMBLY AND MAN-TENDED PHASES.
- TECHNOLOGY FOR INITIAL SSF GROUND SYSTEMS IS WELL-UNDERSTOOD AND EXCEPT FOR HIGH RATE FRONT END PROCESSING IS PRIMARILY NOT A TECHNICAL CHALLENGE
- DUE TO EVOLVING CONFIGURATION, INITIAL AUTOMATION WILL BE MODEST.
- AUTOMATION IS CRITICAL TO LONG-TERM COST-EFFECTIVENESS OF GROUND OPERATIONS.
- SEVERAL EMERGING TECHNOLOGIES HAVE LARGE POTENTIAL BENEFIT TO GROUND OPERATIONS.
- CHALLENGE IN GROUND SYSTEMS DESIGN IS ARCHITECTURE DESIGNED TO ACCEPT EMERGING TECHNOLOGIES.

EMERGING TECHNOLOGIES CAN POTENTIALLY BENEFIT GROUND OPERATIONS

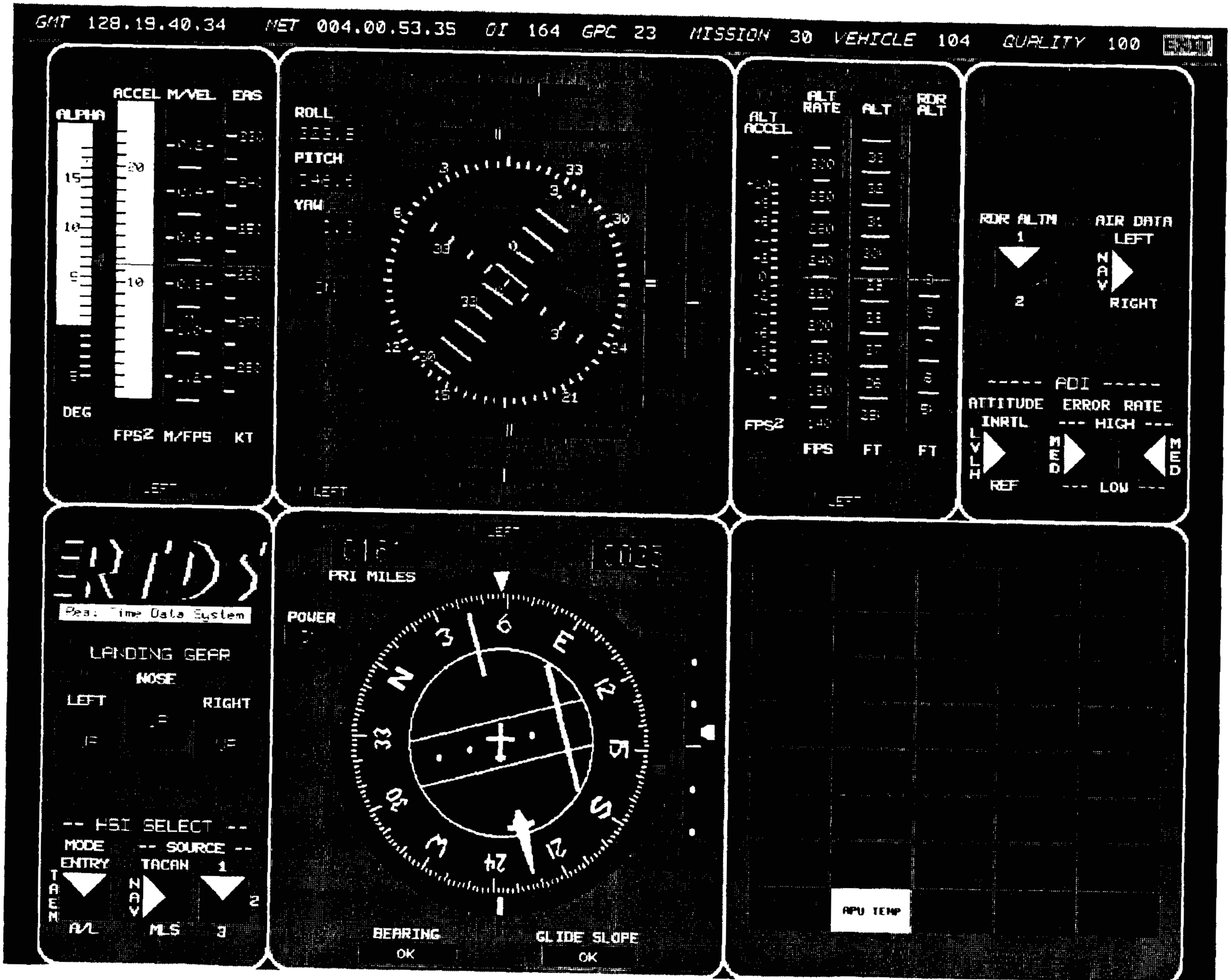
- KNOWLEDGE BASED SYSTEMS - (RULE AND MODEL BASED)
- NETWORKING STANDARDS (ISO)
- WINDOWING AND GRAPHICS STANDARDS
- NEUTRAL NETWORKS
- REMOTE TELEROBOTIC OPERATIONS
- PARALLEL PROCESSING
- HIGH DEFINITION TV
- IMPROVED HUMAN/COMPUTER INTERFACES
- COMPUTER AIDED SOFTWARE ENGINEERING/SOFTWARE SUPPORT ENVIRONMENTS
- OPTICAL DISK
- DIGITAL VIDEO
- HYPERMEDIA
- NEW CPU TECHNOLOGIES
- ADA

CHALLENGE IS TO STRUCTURE GROUND SYSTEMS TO ACCEPT EMERGING TECHNOLOGIES

- RTDS IS EXAMPLE MODEL - SHADOW FORCE
  - INTRODUCE NEW TECHNOLOGY IN PARALLEL IN OPERATIONAL LOCATION.
  - EVALUATE BY COMPARISON.
  - BACK OUT OLD TECHNOLOGY AS CONFIDENCE ESTABLISHED.
  - SHADOW APPROACH.
- T-FCR IS ALTERNATIVE MODEL - ALL UP APPROACH
  - BUILD ENTIRE CONTROL CENTER AND OPERATE IN PARALLEL.

Figure 7.- Console of the Integrated Communications Officer in the Mission Contr Center.

Figure 8.- Conventional INCO workstation (left) and Shuttle INCO Expert System (right).



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ATTITUDE
ERROR
RATE
INRTL
--- HIGH ---
LVLH
MED
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RTDS
Real Time Data System
LANDING GEAR
NOSE
LEFT
RIGHT
-- HSI SELECT --
MODE
ENTRY
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-- SOURCE --
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MLS
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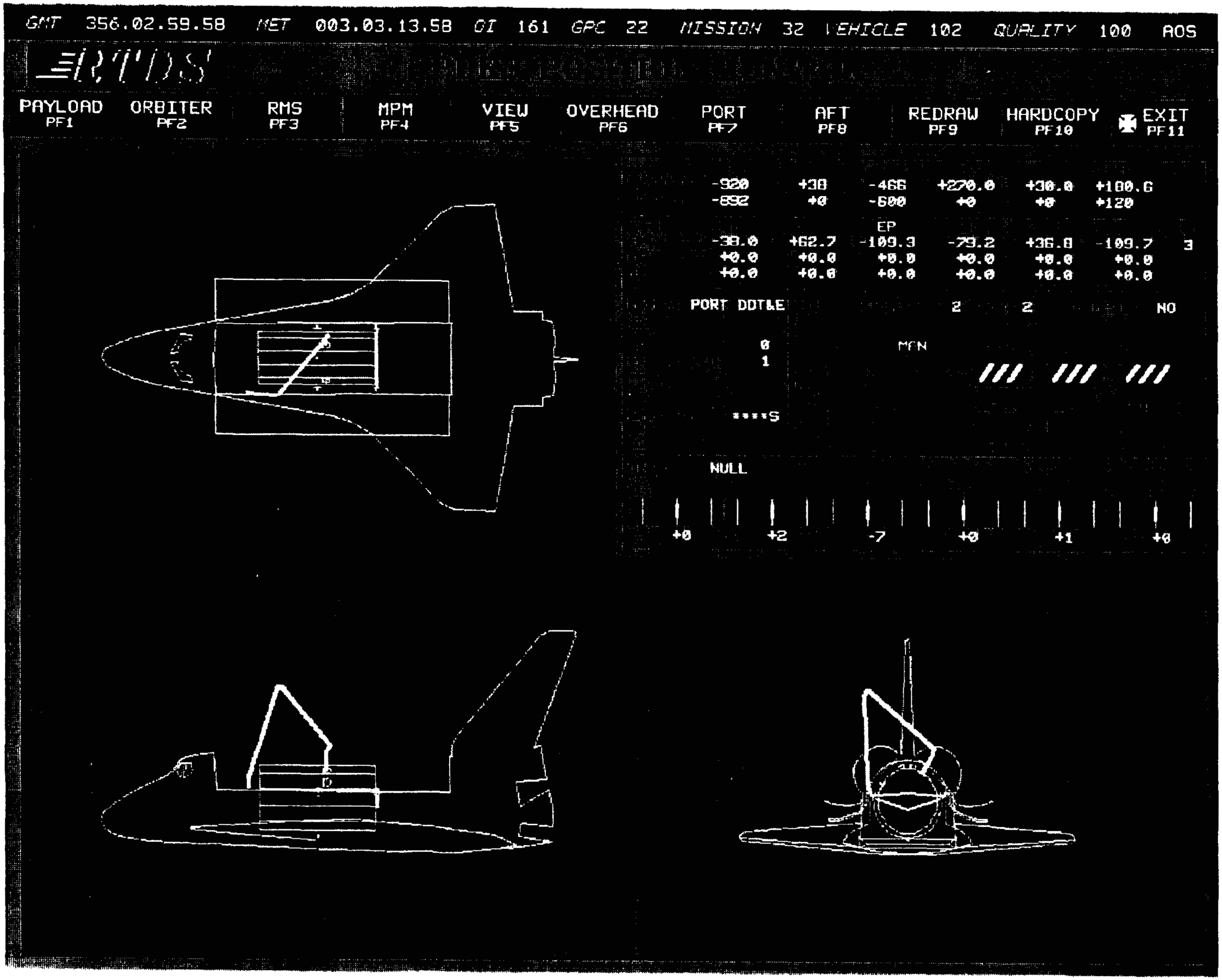
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MPM PF4
VIEW PF5
OVERHEAD PF6
PORT PF7
AFT PF8
REDRAW PF9
HARDCOPY PF10
EXIT PF11
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-892 +0 -600 +0 +0 +120
EP
-38.0 +62.7 -109.3 -79.2 +36.8 -109.7 3
+0.0 +0.0 +0.0 +0.0 +0.0 +0.0
+0.0 +0.0 +0.0 +0.0 +0.0 +0.0
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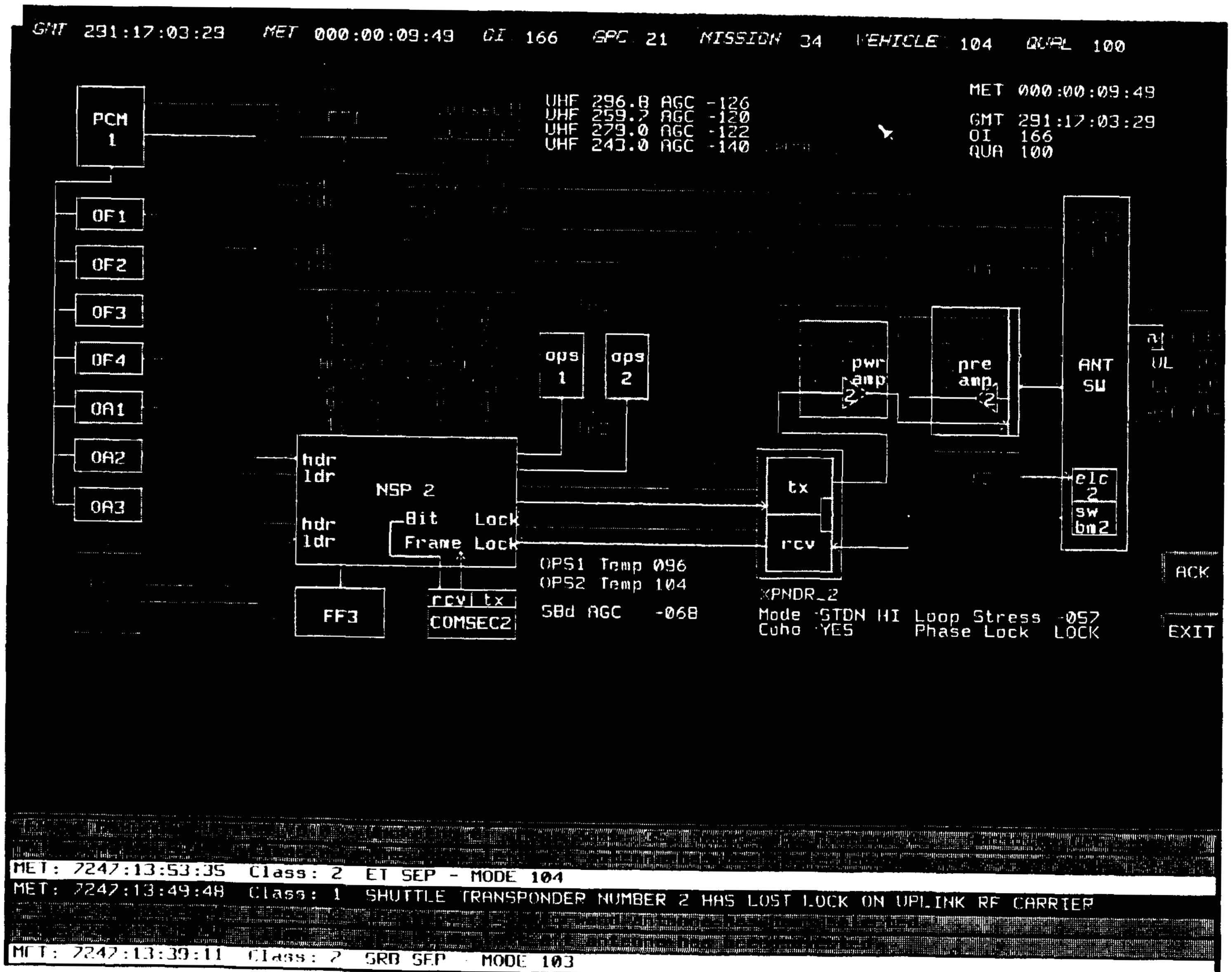
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OA2
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hdr ldr
Bit Lock
Frame Lock
FF3
rcv tx
COMSEC2
OPS1 Temp 096
OPS2 Temp 104
SBd AGC -068
pwr amp 2
pre amp 2
ANT SW
elc 2
sw bm2
tx
rcv
XPNDR_2
Mode STDN HI
Coho YES
Loop Stress 057
Phase Lock LOCK
UL
ACK
EXIT
MET: 7247:13:53:35 Class: 2 ET SEP - MODE 104
MET: 7247:13:49:48 Class: 1 SHUTTLE TRANSPONDER NUMBER 2 HAS LOST LOCK ON UPLINK RF CARRIER
MET: 7247:13:39:11 Class: 2 SRB SEP MODE 103

ARCHITECTURAL KEYS TO INTRODUCING NEW TECHNOLOGY

USING SHADOW STRATEGY

- ISOLATION OF NEW TECHNOLOGY FROM MISSION CRITICAL PROCESSES
- CONNECTIVITY TO REAL TIME DATA
- PLACEMENT IN OPERATIONS LOCATION
- OPERABILITY
- REAL TIME PERFORMANCE
- RAPID CHANGE ACCOMMODATED ("FIREWALL" TO CONTAIN CHANGE)

HARD VS. SOFT REAL TIME

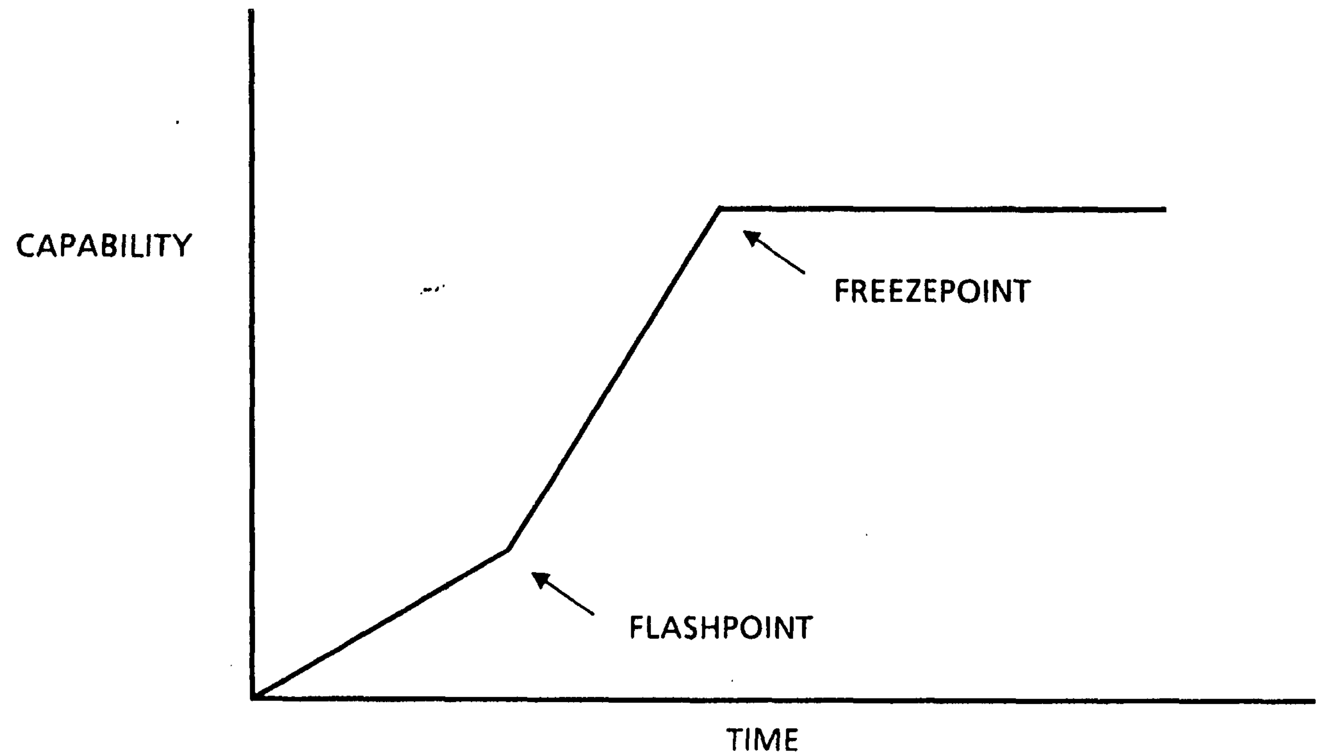
- HARD REAL TIME - IF TIME CONSTRAINTS NOT MET THEN FUNCTION FAILS.
- SOFT REAL TIME - IF TIME CONSTRAINTS NOT MET THEN FUNCTION DEGRADED.
- MOST REAL TIME INTELLIGENT ASSISTANTS MONITORING TASKS ARE SOFT REAL TIME.
- DIFFERENCE BETWEEN HARD AND SOFT REAL TIME NOT WELL-UNDERSTOOD - CAUSES EXCESSIVE DEMANDS/EXPECTATIONS ON SYSTEM DESIGN.
- DISPLAY REQUIREMENT IS TRADITIONALLY ONCE PER SECOND - BUT OPERATIONS DO NOT PERFORM EVALUATIONS AT ONCE/SECOND EVERY SECOND (HARD CONSTRAINT).
- REAL TIME EXPERT SYSTEMS DO NOT HAVE TO RUN 1/SECOND AT ALL TIMES TO HAVE BENEFIT IN MOST (SOFT R/T) APPLICATIONS

  EXAMPLE: 90% 1/SEC
  5% 1/2 SEC
  5% 1/2 SEC
- IS ACCEPTABLE IN TELEMETRY MONITORING TASKS DURING NONDYNAMIC FLIGHT

RTDS - REAL TIME DATA SYSTEM

- INTRODUCED SEVERAL NEW TECHNOLOGIES TO MCC.
- USED OPERATIONALLY ON EIGHT FLIGHTS SO FAR (STS-26 TO STS-32).
  - COLOR GRAPHIC R/T SCHEMATICS AND TELEMETRY BASED ANIMATED VISUALS.
    - RMS (STS-32)
    - FLIGHT INSTRUMENT EMULATION (STS-29)
  - RULE-BASED EXPERT SYSTEMS (INCO, STS-26, GNC STS-32).
  - TASK AUTOMATION (TIRE PRESSURE MONITOR (STS-30).
  - COMMERCIAL OFF THE SHELF TELEMETRY PROCESSOR (STS-26).
  - ETHERNET FOR DATA DISTRIBUTION TO OFFICE ENVIRONMENT (STS-29).
  - THERMAL PRINTING STRIP CHART RECORDERS (STS-29).
  - COLOR HARDCOPY (THERMAL WAX) (STS-30).
  - COMP AND DISPLAY BUILDER TOOLS (STS-26, STS-29).

TECHNOLOGY INSERTION CURVE



FLASHPOINT - WHEN NEW TECHNOLOGY HAS ENOUGH DEMONSTRATED CAPABILITY TO EXCITE USERS

FREEZEPOINT - WHEN USERS RELYING ON NEW TECHNOLOGY AND REQUIRE OPERATIONAL RELIABILITY

CRITICAL REQUIREMENTS

- ABILITY TO RECORD AND PLAYBACK.

- ELECTRICAL ACCESS TO DESIGN INFORMATION.

REAL TIME DATA SYSTEM

BACKGROUND

- MISSION OPERATIONS DIRECTORATE PROJECT THAT UTILIZES:
  - ARTIFICIAL INTELLIGENCE (AI) TECHNIQUES
  - COMMERCIAL OFF-THE-SHELF COMPUTER AND TELEMETRY EQUIPMENT

TO:

- CAPTURE CORPORATE KNOWLEDGE ABOUT SHUTTLE MONITORING
- PRESENT DATA WITH COLOR GRAPHICS TO REDUCE TRAINING, FLIGHT CONTROLLER WORKLOAD AND PROBABILITY OF ERROR
- UPGRADES MISSION CONTROL CAPABILITIES RAPIDLY WITHOUT RISK TO EXISTING COMPLEX
- SUPPORTS LARGER MISSION CONTROL CENTER UPGRADE (MCCU) PLANS BY PROVIDING IMMEDIATE EXPERIENCE WITH CRITICAL TECHNOLOGIES

Real Time Data Systems: Incorporating New Technology in Mission Critical Environments

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BACKGROUND

Real Time Data System (RTDS) is a Mission Operations Directorate (MOD) project that utilizes Artificial Intelligence (AI) and commercial off-the-shelf computer and telemetry equipment to: (1) capture corporate knowledge about shuttle monitoring, (2) present data with color graphics to reduce operator training time, and (3) reduce flight controller workload and probability of error. RTDS has upgraded Mission Control capabilities rapidly without risk to the existing complex. Additionally, RTDS supports the larger Mission Control Center Upgrade (MCCU) plans by providing immediate experience with critical technologies such as real time expert systems.

RTDS has been used by flight controllers in Mission Control since the flight of Discovery in September 1988. Since that time it has expanded in size and scope providing an operational testbed for promising new technolgies and transitioning proven technologies to flight operational status for addition to the flight controller tool base.

REAL TIME DATA SYSTEM

APPROACH

- ISOLATE NEW TECHNOLOGY FROM CRITICAL SYSTEMS
- CONNECT TO REAL-TIME DATA
- GENERATE RESULTS IN REAL TIME
- LOCATE EQUIPMENT AT FLIGHT CONTROLLER POSITIONS
- "FIREWALL" SOFTWARE TO ISOLATE THE EFFECTS OF CHANGE AND ALLOW RAPID PROTOTYPING

APPROACH

In past programs, NASA managers have been reluctant to rely on new technologies for mission critical activities until they are proven in non-critical areas. With RTDS, NASA-MOD has developed a non-traditional method for migrating the new technologies more rapidly into the operator tool base by "field testing" them in the mission critical environment of Mission Control. This approach mandates several important requirements.

- **ISOLATE NEW TECHNOLOGY FROM CRITICAL SYSTEMS**

Isolatation is a key ingrediant when hosting new technologies within an operational environment. The new technology must be isolated from existing systems to avoid inducing problems with the trusted system. On the flip side, the problems or deficiencies of the previous system should not be induced into the new technology through design dependancies. The strategy of isolation works especially well in Mission Control as the older system is main frame based and not espesially forgiving of change and does not easily connect to the new workstation platforms.

- **CONNECT TO REAL-TIME DATA**

Connectivity to real time data is an absolute necessity; real time data is to the flight controller as lumber is to the carpenter. The characterstics of the data will drive the design of the overall system as well as the individual applications.

APPROACH (CONT.)

- **GENERATE RESULTS IN REAL TIME**

In Mission Control the operator must see data and results of computer based monitoring applications in real time. The definition of real time changes from system to system, but in generic terms means the ability to generate results in time for the operator to effect corrective changes in system configuration based on those results.

- **LOCATE EQUIPMENT AT FLIGHT CONTROLLER POSITIONS**

Laboratory prototyping is a good way to experiment with new technologies, but is a "gee-wiz" activity as far as line flight controllers are concerned. If the flight controller can't test-drive the new technology in his natural environment, the really important lessons are not discovered until its too late to effect the necessary changes. Issues of operability arise under the stress of real operations.

- **"FIREWALL" SOFTWARE TO ISOLATE THE EFFECTS OF CHANGE AND ALLOW RAPID PROTOTYPING**

Complex data systems have to be tolerant of change. Change is motivated by advances in the technology, a desire to add new capabilities, or the need to modify existing ones. The software life cycle chosen by the RTDS team placed further requirements on the ability of the system to withstand change. Selected applications are used operationally in a mission critical environment; these require a high degree of host system stability. Other less mature applications may require additional system level capabilities not found in the previous host systems. By "firewalling" the system, and maintaining upward compatibility the overall system is made tolerant of change.

REAL TIME DATA SYSTEM

RESULTS

- SIGNIFICANT KNOWLEDGE CAPTURED IN AUTOMATED MONITORING
- ABLE TO DO MORE WORK WITH SAME RESOURCES
  - INCO TEAM BEING REDUCED FROM FOUR TO THREE IN LATE FY90
- RTDS PROCESSES DATA 3-4 SECONDS FASTER THAN MAIN FRAME
- UPGRADING CAPABILITIES IN PARALLEL WITH ONGOING OPERATIONS WITH NO RISK TO FACILITY
  - REPLACED THREE DISPLAY CONSOLES WITH RTDS DISPLAYS
  - INSTALLED EIGHT RTDS DISPLAYS ON CONSOLES
  - ATTACKING BACKLOG OF POSTPONED RQMTS IN MAINFRAME BY PLACING THEM IN WORKSTATIONS
  - IMPLEMENTED 6 ALGORITHMS IN WORKSTATIONS THAT HAD MAINFRAME ESTIMATED COSTS OF $10-100K EACH
  - SOFTWARE TOOLS DEVELOPED IN RTDS HAVE BEEN BASELINED IN MISSION CONTROL CENTER UPGRADE

RESULTS

- **SIGNIFICANT KNOWLEDGE CAPTURED IN AUTOMATED MONITORING**

RTDS employs both algorithmic and heuristic knowledge representation schemes. C language code and rules are used for those tasks requiring a high rate of execution. Rule based systems such as the C Language Inference Production System (CLIPS by NASA-JSC) and Gensym's G2 software are used to capture more complex determistic and heuristic knowledge. Over three hundred real time algorithms have been developed and tested and are used routinely by flight controllers in Mission Control for fault detection. Real time expert systems have been developed and operated in several disciplines including Integrated Communications Officer (INCO), and Guidance, Navigation and Control (GNC). The majority of these applications could not have been developed on the existing main frame system; the ones that could would have been done at considerably greater cost.

- **ABLE TO DO MORE WORK WITH SAME RESOURCES**

Prior to RTDS the flight controller had to keep eyes on the data, since little or no automated monitoring is done by the main frame. Through automated monitoring and fault detection RTDS has provided a means for the flight controller to work other issues such as mission planning. If a problem does arrise, the flight controller is notified by RTDS.

- **INCO TEAM BEING REDUCED FROM FOUR TO THREE**

The INCO flight controllers are using RTDS capabilities to automate one of their back room positions. The Data Communications (DATACOMM) Officer is responsible for monitoring and controlling the Orbiter's flight recorders. A preliminary system will be tested in early Summer, with the full-up system ready by the end of the year. Though the DATACOMM expert system will not initially have command capability to the orbiter it will automate the bulk of the DATACOMM's activities which include data and system configuration management, fault detection and resolution.

RESULTS (CONT.)

- **RTDS PROCESSES DATA 3-4 SECONDS FASTER THAN MAIN FRAME**

Using commercial off-the-shelf telemetry processing equipment and general purpose engineering workstations RTDS is able to put processed real time data up on a display 3-4 seconds faster than the main frame. During the dynamic phases of flight those few seconds can be used to make higher quality decisions which can affect the successful outcome of the flight.

- **UPGRADING CAPABILITIES IN PARALLEL WITH ONGOING OPERATIONS WITH NO RISK TO FACILITY**

One of the prime concerns with installing new technology into a mission critical area is how it affects existing capabilities. RTDS took the standpoint early on that the new technology had to be installed in the Mission Control Center, but isolated from the existing main frame complex. In this way, RTDS does not interact in any way with the existing system. The existing system remains in place until sufficient confidence has been built in the new system.

  - **REPLACED THREE DISPLAY CONSOLES WITH RTDS DISPLAYS**

Three RTDS displays have been placed inside of flight controller consoles displacing the main frame displays. This represents the first time in almost twenty years that the existing console hardware has been removed to accomadate newer technology. Replacement was done after extensive side-by-side testing in simulations and flight. This replacement represents a significant step in the upgrade process.

  - **INSTALLED EIGHT RTDS DISPLAYS ON CONSOLES**

Eight RTDS displays have been placed on or next to flight controller consoles. These displays are used for side-by-side testing of operational and near operational real time applications during simulations and flight. Flight controllers use these displays routinely to build confidence in their new operator tools.

RESULTS (CONT.)

- **ATTACKING BACKLOG OF POSTPONED RQMTS IN MAINFRAME BY PLACING THEM IN WORKSTATIONS**

There currently exists a backlog of requirements waiting to be implemented in Mission Control's main frame complex. Each new main frame requirement which is instituted costs many thousands of dollars and takes a team of programmers to implement. There is a natural reluctance to implement these requirements for fear of adversely affecting existing capabilities. RTDS has implemented many of these requirements. The Main Engine application is a good example of how RTDS has implimented new capabilities in rapid fashion. The Main Engine application was developed and certfied for flight in three months.

- **SOFTWARE TOOLS DEVELOPED IN RTDS HAVE BEEN BASELINED IN MISSION CONTROL CENTER UPGRADE**

RTDS has developed many tools and techniques which did not previously exist on any other systems or in the commercial world. The Computation Development Environment (CODE) was developed in RTDS to enable flight controllers with little or no programming experience to implement real time C language algorithms. CODE has since been baselined for use in the larger Mission Control Center Upgrade project, the Space Station Control Center, and the Multi-Purpose Control Center.

Providing time homogenous real time telemetry data to real time applications on multi-tasking workstations poses some interesting challenges. RTDS has developed an innovative multi-buffer design to accomadate the requirements of the data and the characteristics of the UNIX operating system. This design and the driver routine have been adopted by Mission Control Center Upgrade project.

REAL TIME DATA SYSTEM

PRODUCTS

INCORPORATED INTO OPS TOOL BASE

- MAIN ENGINE WORKSTATION MORE CAPABLE THAN MAINFRAME (SINCE STS-26)
- INCO SYSTEM HAS SIGNIFICANTLY REDUCED TIME TO FAULT DETECTION (SINCE STS-26)
  - DETECTED FAILURES DURING STS-34, STS-32
- RMS APPLICATION USES REAL TIME ANIMATION TO PROVIDE REAL-TIME VISUALIZATION AND ERROR DETECTION (STS-32)
  - USED EXTENSIVELY DURING LDEF GRAPPLE & PHOTO SURVEY
- FLIGHT INSTRUMENTS USED SINCE STS-29
- MECHANICAL SYSTEMS TIRE PRESSURE APPLICATION

  (STS-34, STS-33, STS-32)
- RTDS TELEMETRY CAPABILITY IS PORTABLE AND PROVIDES EMERGENCY MISSION CONTROL CENTER CAPABILITY (TESTED DECEMBER 1987 & DURING STS-32)
- RTDS TELEMETRY AND REAL TIME EXPERT SYSTEM SOFTWARE TRANSFERRED TO OAST AERONAUTICS (INTEGRATED TEST FACILITY AT DFRF) AND USAF (F-15 STOL PROJECT AT EAFB)
- REAL TIME SOFTWARE USED BY JSC ENGINEERING DIRECTORATE FOR PRE-LAUNCH INERTIAL MEASUREMENT UNIT EVALUATION

PRODUCTS

INCORPORATED INTO OPS TOOL BASE

- **MAIN ENGINE WORKSTATION MORE CAPABLE THAN MAINFRAME (SINCE STS-26)**

In May of 1988 the flight controllers responsible for monitoring the main engines determined that there were several failure modes of the main engine which required automated monitoring. The flight controllers could not manually perform the calculations and assessments fast enough to meet the demands of monitoring this high performance system in dynamic flight. The necessary fault-detection routines were designed and built using RTDS. The system was certified for use in August 1988 and was used operationally during STS-26 in September 1988. The system has since been expanded and re-certified several times in order to handle other automated monitoring tasks which are not done in the main frame.

- **INCO SYSTEM HAS SIGNIFICANTLY REDUCED TIME TO FAULT DETECTION (SINCE STS-26)**

During simulations in mission control the INCO system routinely detects failure conditions before the operator can detect them on the main frame display. The main frame display system can not display all the data about all the systems simulataneously. Therefore the data which indicate a failure might not be visible to the flight controller at the time of the failure. The algorithms built into the INCO system check hundreds of parameters each second. If these algorithms detect a failure condition they annunciate on the RTDS display with a color coded message. The INCO algorithms were designed and implimeted by INCO flight controllers.

PRODUCTS (CONT.)

- **DETECTED FAILURES DURING STS-34, STS-32**

During STS-34 the INCO system detected a fault with the Orbiter's Sband quad antennas and annunciated it on the RTDS display. This failure condition, though visible on the main frame display, was detected first by flight controllers monitoring the RTDS display.

During STS-32, multiple failures of the Orbiter's Text and Graphics System (TAGS) where detected first by flight controllers monitoring the RTDS display.

- **RMS APPLICATION USES REAL-TIME ANIMATION TO PROVIDE REAL-TIME VISUALIZATION AND ERROR DETECTION (STS-32)**

The Remote Manipulator System (RMS) application is aptly called the Position Monitor. The Position Monitor uses real time data to dynamically display the position of the Orbiter's Remote Manipulator System or Arm. Position Monitor allows the flight controllers to visualize the position and movements of the Arm in real time. As the Arm does not have a collision avoidance system real time visualization is especially important.

- **FLIGHT INSTRUMENTS USED SINCE STS-29**

- **MECHANICAL SYSTEMS TIRE PRESSURE APPLICATION (STS-34, STS-33, STS-32)**

The Tire Pressure application provides the Mechanical Systems flight controllers with real time trend analysis of the Orbiter's tires. Similar to the RMS application, Orbiter tire pressures were previously typed into a portable computer and graphed using Lotus 1-2-3. The data is now automatically logged and plotted on their RTDS display, freeing up the flight controllers to do more important tasks.

PRODUCTS (CONT.)

- **RTDS TELEMETRY CAPABILITY IS PORTABLE AND PROVIDES EMERGENCY MISSION CONTROL CENTER CAPABILITY (TESTED DECEMBER 1987 & DURING STS-32)**

The RTDS telemetry system is portable and rugged. The RTDS telemetry system has been used to provide real time data for the Emergency Mission Control Center since 1987. In the event of a natural disaster occuring at JSC in which all monitoring capabilities were lost at the Mission Control Center a small team of flight controllers would be flown out to White Sands, New Mexico equipped with the RTDS system. The data and displays provided by RTDS would be used by flight controllers to calculate proper trajectory for de-orbit and safe return.

- **RTDS TELEMETRY AND REAL TIME EXPERT SYSTEM SOFTWARE TRANSFERRED TO OAST AERONAUTICS (INTEGRATED TEST FACILITY AT DFRF) AND USAF (F-15 STOL PROJECT AT EAFB)**

- **RTDS REAL TIME SOFTWARE USED BY JSC ENGINEERING DIRECTORATE FOR PRE-LAUNCH INERTIAL MEASUREMENT UNIT EVALUATION**

REAL TIME DATA SYSTEM

PRODUCTS

TESTING PHASE

- REAL TIME EXPERT SYSTEMS DEVELOPED USING COTS REAL TIME EXPERT SYSTEM TOOL (GENSYM'S G2)
  - GNC AIR DATA PROBES DURING STS-34, STS-32
  - INCO FLIGHT RECORDERS DURING STS-34, STS-32
  - GNC CONTROLLABILITY DURING STS-32
- LANDING SITE SELECTION APPLICATION TESTED IN WEATHER OFFICE DURING STS-32
- PAYLOAD BAY DOOR APPLICATION MONITORS DATA NOT YET AVAILABLE ON MAINFRAME (STS-32)
- DEMONSTRATED REMOTE MONITORING CAPABILITY

PRODUCTS

TESTING PHASE

- **REAL TIME EXPERT SYSTEMS DEVELOPED USING COTS REAL TIME EXPERT SYSTEM TOOL (GENSYM'S G2)**

G2 is a commercial off-the-shelf real time rule based expert system shell which has previously been used in process control applications. The software is a product of the Gensym Corporation. The software provides many of the robust knowledge acquistion capabilities necessary for building and maintaining distributed real time applications. G2 has been used by RTDS to rapidly develop several real time expert systems.

- **GNC AIR DATA PROBES DURING STS-34, STS-32**

The Guidance, Navigation & Control (GNC) Officer's Air Data Probe expert system was developed to monitor the Orbiter's two air data probes during descent. The system has been tested during STS-34 and STS-32. Air Data Probe expert system represents RTDS's first use of commercial off-the-shelf expert system tools.

- **INCO FLIGHT RECORDERS DURING STS-34, STS-32**

The INCO Ops Recorders expert system will be used as the basis for position automation at the DATACOMM position. The DATACOMM is the flight controller responsible for operating the Orbiter's flight recorders.

- **GNC CONTROLLABILITY DURING STS-32**

The GNC Controllability expert system has been developed to monitor the Orbiter's computer control during powered flight. This system was tested during STS-32.

- **LANDING SITE SELECTION APPLICATION TESTED IN WEATHER OFFICE DURING STS-32**

Weather data concerning Shuttle runways is currently recieved by the Mission Control Center weather office and verbally conveyed to the flight director over the MCC voice loops. These voice loops are very busy during the dynamic phases of flight and information transfer via voice loop can become difficult. The Landing Site Selection application recieves the real time data electronically and displays it on a color graphics workstation. One of these workstations has been installed in the JSC Weather office and was tested during STS-32. A second workstation will be installed this summer at the Flight Director console. This will provide the Flight Director direct access to the weather information and cut down on voice loop traffic during dynamic phases of flight.

- **PAYLOAD BAY DOOR APPLICATION MONITORS DATA NOT YET AVAILABLE ON MAINFRAME (STS-32)**

The Payload Bay Door application is another RTDS only capability. The data provided by this display is not available on the main frame and will not be for some years to come. This application was tested during STS-32 and will be made operational by STS-35.

- **DEMONSTRATED REMOTE MONITORING CAPABILITY**

RTDS has developed the capability to transmit real time data via standard Ethernet and data phones. These capabilities were originally designed to provide an office monitoring capability for flight controllers. The capabilities have since proven invaluable in providing data to applications developers who do not have direct access to RTDS telemetry processing equipment.

REAL TIME DATA SYSTEM

FY90 ACTIVITIES

- EXTEND RTDS SUPPORT TO DPS, FLIGHT DIRECTOR, EGIL, EECOM AND POINTING FLIGHT CONTROL DISCIPLINES (STS-35)
- VISION SYSTEM TO ASSIST ORBITAL MANEUVERING VEHICLE (OMV) PILOT GUIDE OMV DURING PROXIMITY OPERATIONS (FALL 1990)
- DISTRIBUTED COOPERATIVE EXPERT SYSTEM FOR BUS LOSS (STS-37)
- EXPAND REMOTE MONITORING CAPABILITY BY PROVIDING ACCESS RTDS DISPLAYS BY FLIGHT CONTROLLER OFFICE COMPUTERS (STS-37)

FY90 ACTIVITIES

- **EXTEND RTDS SUPPORT TO DPS, FLIGHT DIRECTOR, EGIL, AND EECOM CONTROL DISCIPLINES (STS-35)**

- **VISION SYSTEM TO ASSIST ORBITAL MANEUVERING VEHICLE (OMV) PILOT GUIDE OMV DURING PROXIMITY OPERATIONS (FALL 1990)**

The Orbital Maneuvering Vehicle (OMV) shall be limited to two monochrome TV cameras during proximity operations. In order to assist the OMV Pilot in docking procedures a vision system will be developed which uses video input to determine range and attitude. The system shall be installed in the OMV Control Center. RTDS is working closely with vision system experts at the Ames Research Center to develop this capability.

- **DISTRIBUTED COOPERATIVE EXPERT SYSTEM FOR BUS LOSS (STS-37)**

RTDS will develop its first distributed cooperative expert system to monitor Orbiter bus loss. Orbiter Bus Loss has been chosen because the effects of bus loss are felt across multiple flight control disciplines. The problem is well understood and well documented. Orbiter bus loss is currently the responsibility of the EGIL flight controllers.